



Free-flow Hydropower Systems

Partnerships for Renewable Energy in California

California Energy Commission

2005 Water-Energy Relationship Workshop

January 14, 2005

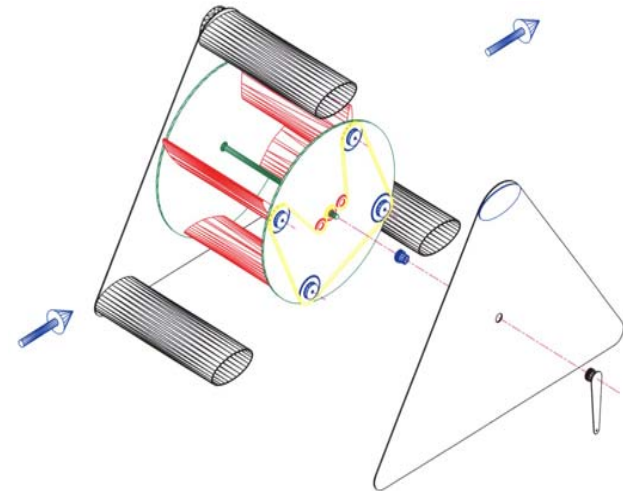
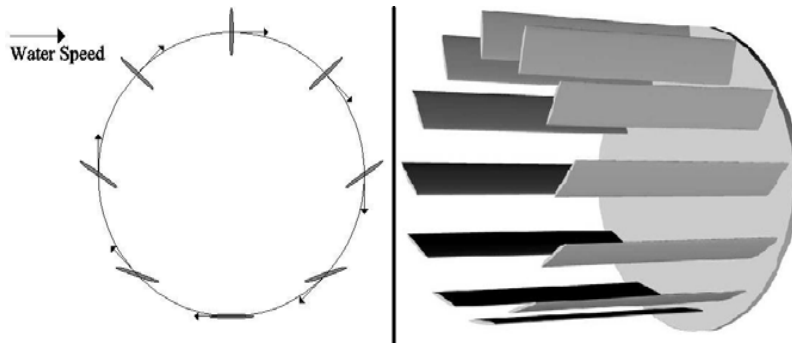


Underwater Free-flow Turbine Array

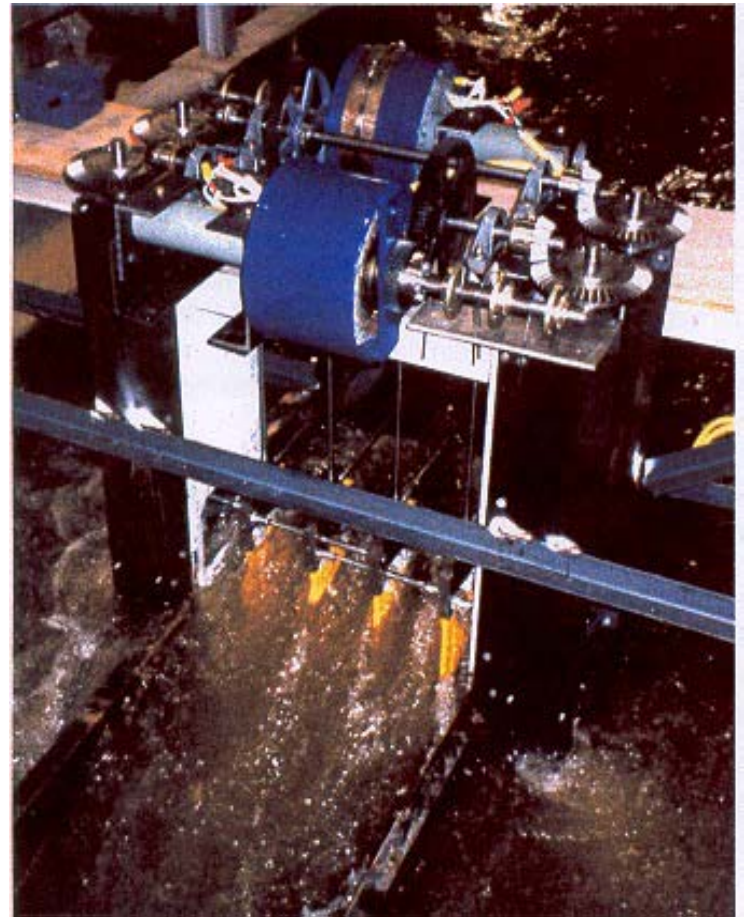
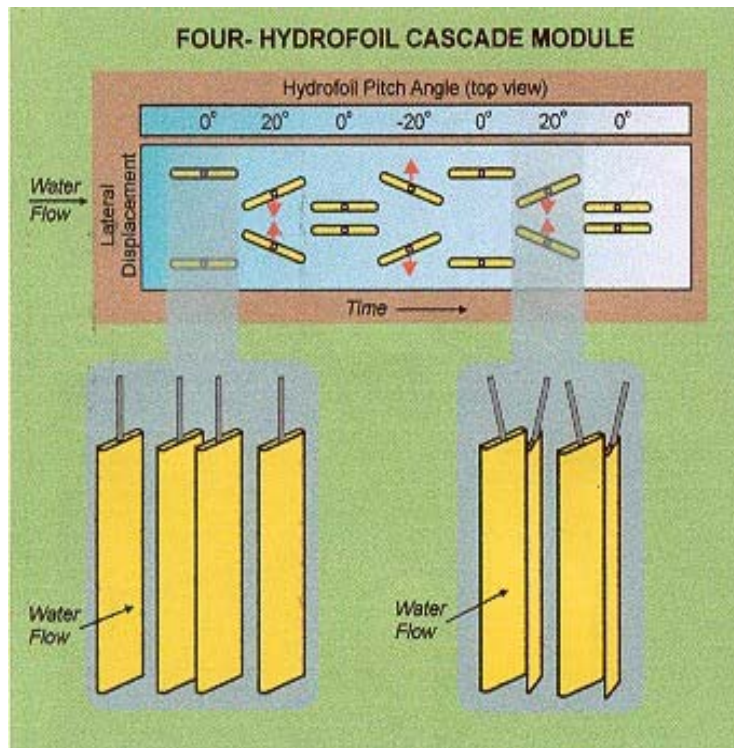


- Five General Families of Free-flow Hydro Technologies
 - Cross-flow Turbines: Darrieus, Helical, & Cycloidal
 - Lift or Flutter-vanes: Cascading & Oscillating Systems
 - Waterwheels: Under & Overshot Paddle Wheels
 - Venturi Systems
 - **Axial-flow Turbines: “Underwater Windmills”**
- Stage of Development
 - Concept (dozens)
 - Bench Test (estimate half of conceptualized)
 - Prototype (~ 10)
 - Commercialized (zero)
- Business/Technical Model
 - **Distributed Generation**
 - Centralized Generation

Cross-flow Turbines: Cycloidal Bench Test, DG



Flutter-vanes: Arnold-Cooper System – Bench Test, DG



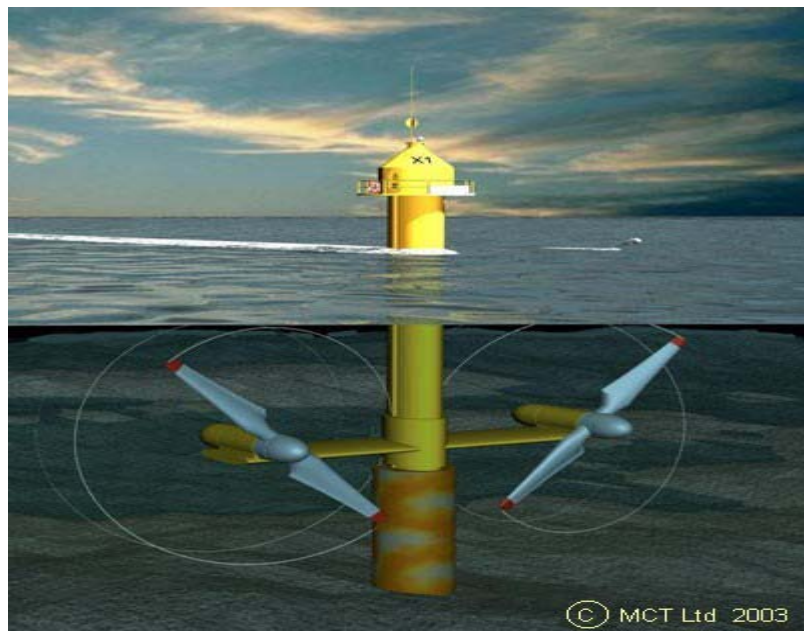
Waterwheels – Prototype, DG



Panorama - early September 1999



Marine Current Turbines (U.K.); Hammerfest Stroem (Norway) Prototype, Centralized Generation





\$90 Billion Global Market for Installations Alone

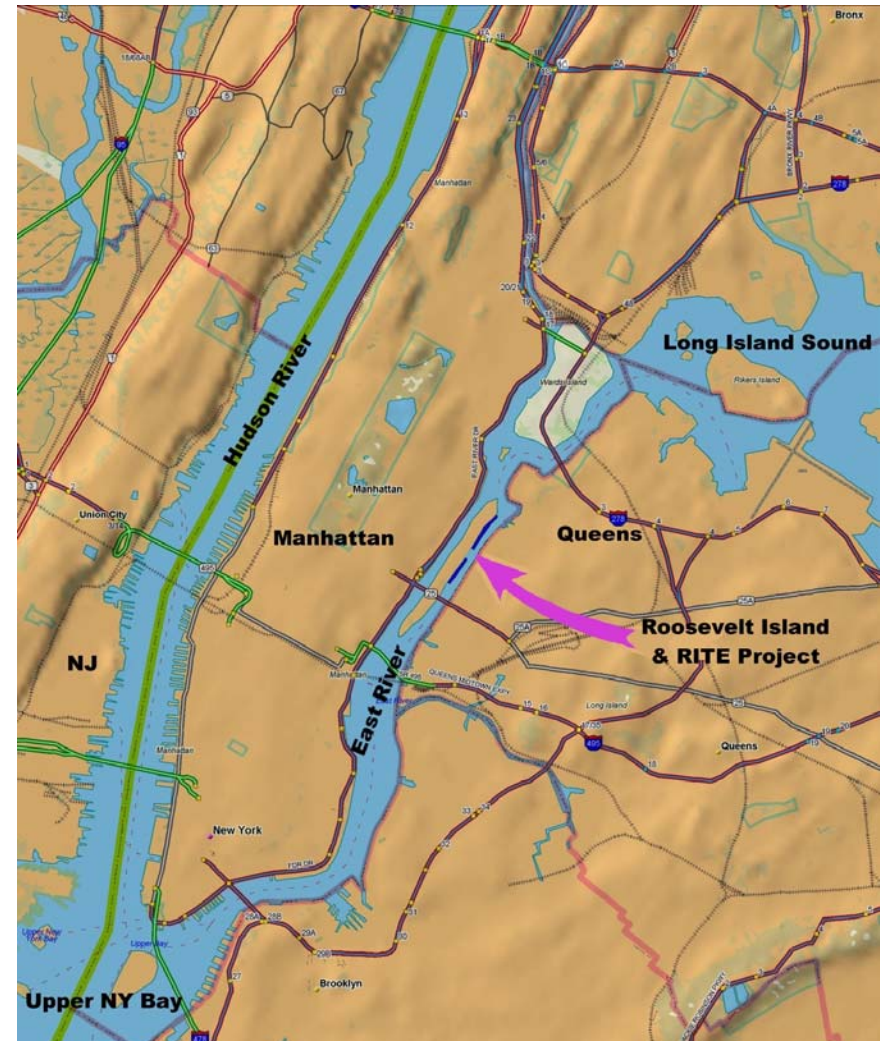
- Global Electricity Demand Increases 173% by 2020
 - *Energy Information Administration*
- Deregulation/Privatization, Technology Favor Small Hydro
 - *EIA / UN Council on Environment & Development*
- U.S. Capacity: 12,500 MW, 120 Sites, \$30 Billion Market
 - *New York University*
- Canada: \$31 Billion; Developing Countries: 1% = \$30 Billion
 - *Natural Resources Council of Canada; DOE/INEEL*
- Hydrogen Production, Purification, Desalinization, Irrigation

- Distributed Generation Hydropower Without Civil Works, Emissions, Visual or Noise Pollution
- Low Unit/Capital Costs (\$1,000 - \$1,500 per kW Installed)
- Competitive O&M (Target < \$0.07 per kWh, Unsubsidized)
- Modular Design, Quick Installation Matches Need, Financing
- Systems Integration - “Water-to-Wire”
 - Identify & Analyze Sites
 - Determine Best Free-Flow Technology
 - Implement Full Solution



DG Development Project - East River, NYC

- Roosevelt Island, East River (Tidal Basin), NYC
- Successful Demonstration Completed January 2003
- 200 kW Commercial System Deployment Pending
- 5 - 10 MW Potential
- Three \$500K Grants (\$1.5M Total) to-date from NYS





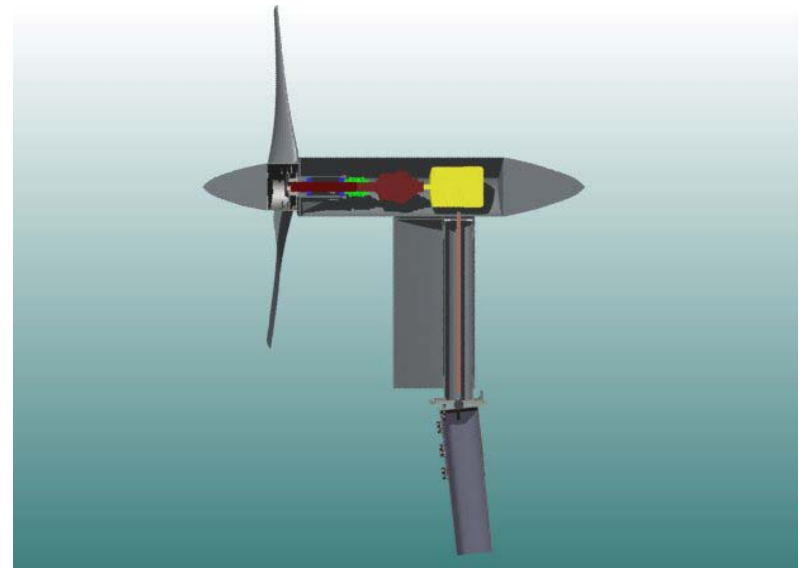
East River Site, NYC





Prototype – January, 2003

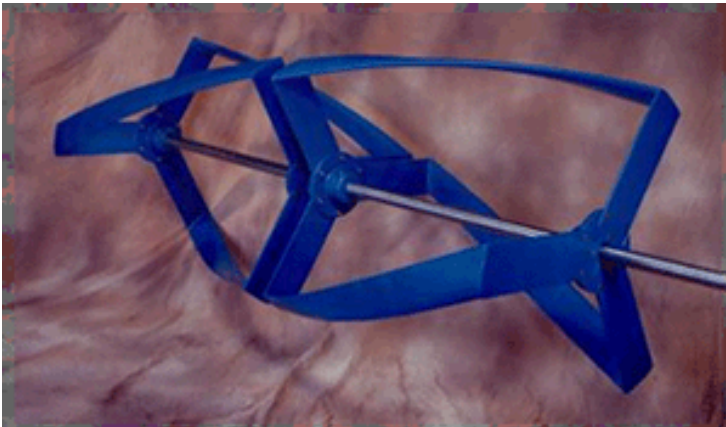
Commercial Unit – May, 2005





DG Development Project – Merrimack River, MA

- Verdant Power Integrates Multiple Technologies
 - MA Awarded \$500K Grant - Verdant Platform, Gorlov Helical Turbine





California Water and Energy Current Issues

- CA uses 265,000 GWh of electricity - growing at 2% - annually
- Water use in California consumes more than 15,000 GWh/year, which is at least 6.5% of the total electricity used by the state
- Peak demand is growing at about 2.4% per year, roughly equivalent to three new 500-megawatt power plants per year
- In 2003, only 77.65% of electricity produced in-state
- Irrigation Canals & Aqueducts (CA: 11,000 miles)
- Preexisting Impoundments: 75,000 U.S. Dams
- Water Discharge Flumes: 9,000 U.S. Power Plants



California Water and Energy Distributed Generation Opportunity

- River, Tidal, and Manmade Channels (canal & aqueducts)
- Incremental Hydro - Existing Hydroelectric Plants
- Flood Control Dams
- Power Plant Discharge Flumes
- Water Sanitation Facilities

- Mokelumne Aqueduct
- Hetch Hetchy Aqueduct (SF PUC)
- *CA Aqueduct (SWP)
- Coastal Aqueduct
- Los Angeles Aqueduct
- Los Angeles Aqueduct #2
- San Diego Aqueduct
- Colorado River Aqueduct

- Coachella Canal
- All-American Canal
- Friant-Kern Canal
- Madera Canal
- Delta Mendota Canal
- South Bay Aqueduct
- Tehema Colusa Canal
- North Bay Aqueduct
- Contra Costa Canal

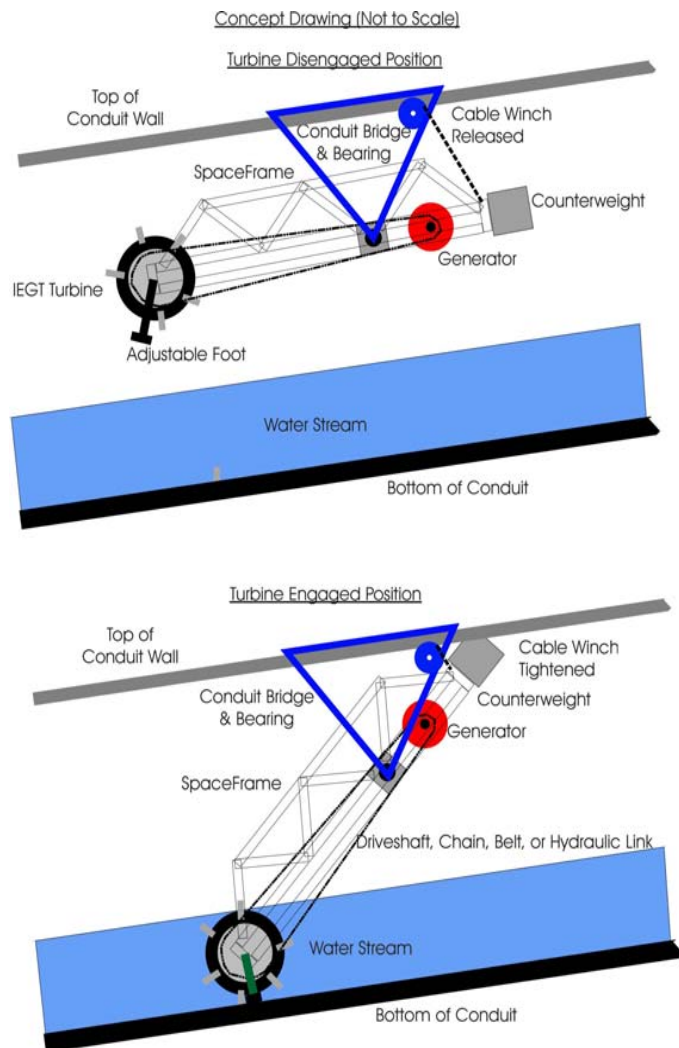


California Water and Energy Example Manmade Channels





California Water and Energy Example Application

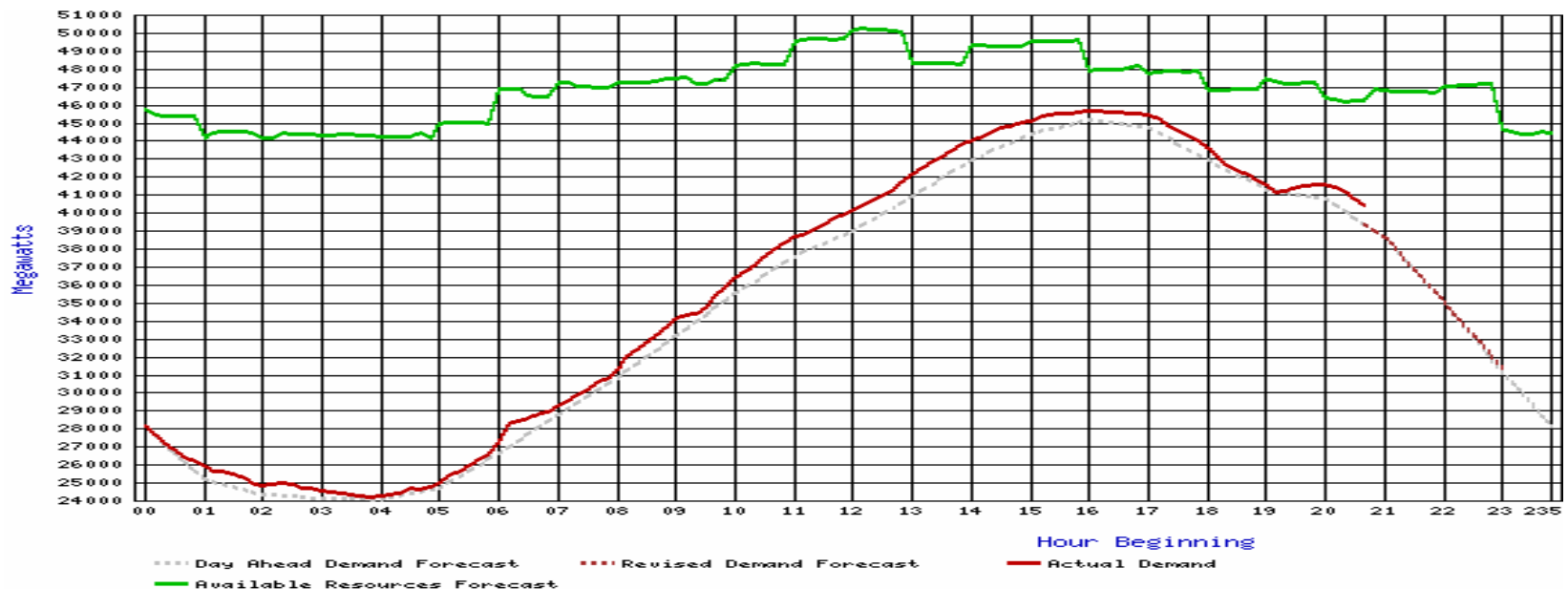




Supply Vs. Demand – 9.8.04 (Partial Slide from Dr. Lon House)

Effective Load-Shifting:

- Irrigation and Water Districts Pump (Consume Power) Off-Peak
- With Free-flow Systems in Irrigation Canals and Aqueducts,
Can Generate During Times of Peak Demand
- **California Has an Enormous “Battery” Infrastructure Already in Place!**



Barrier #1 - Financing

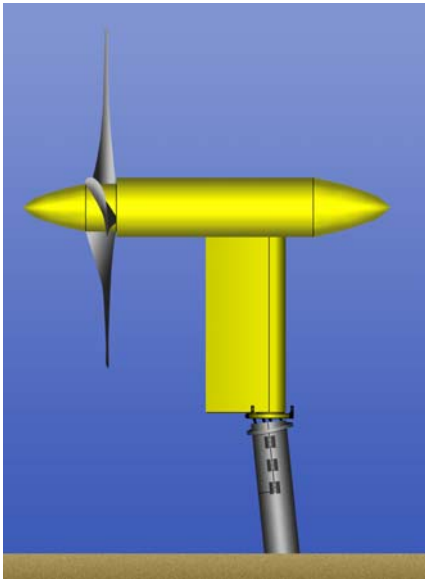
- Capital Finance History: ~ \$7 Million Raised To-Date
 - 4-corner Partnership: Private, Public, NGO/Foundation, Academia
 - Half: \$1.3M from 4 Principals; \$2.3M from Public/NGO Grants
- “The Valley of Death”
 - Founders, Friends/Family, Angels, Public Invest in “Story”
 - These Are the Few Companies that with Successful Prototypes
 - Institutional Investors, Strategic Partners, Public Markets, M&A
 - Need Risk Mitigation & Predictable Pro Forma Projections
- Project Financing
 - Innovation Often Comes from Government, Academia, Start-ups
 - Lack Balance Sheet for Capital Intensive Projects

Barrier #2 - Regulatory

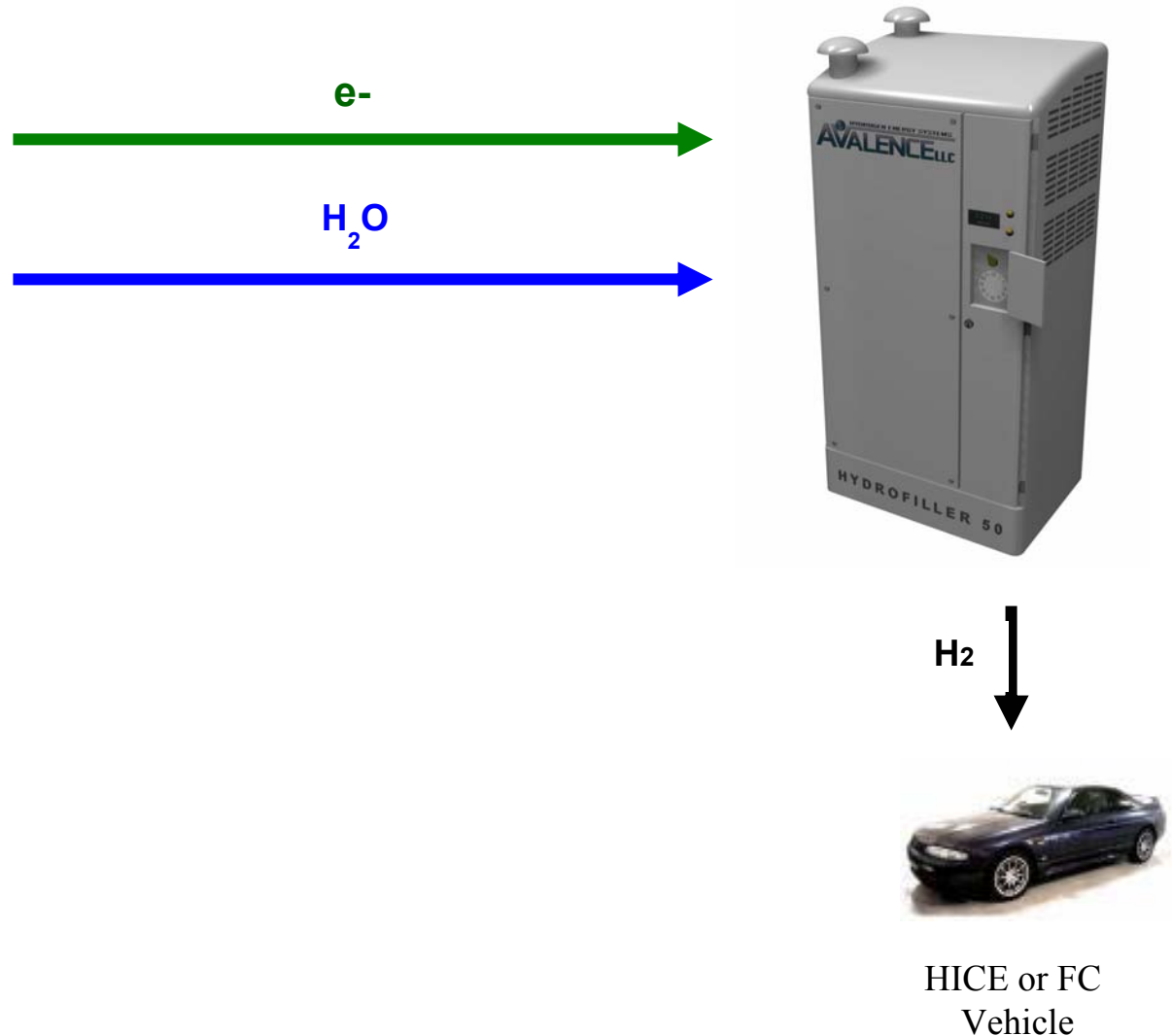
- Current Regulatory Climate in U.S. Not Designed for Innovation
 - Same Process in East River as for a Dam
 - Mandate from FERC Chairman Pat Wood III to Re-design
- Simultaneous Effort – Manmade Channels
 - Often “No Boats and No Fish”
 - Institutional Investors, Project Financiers, Public Markets, M&A
- We Are on the Same Team!
 - Need for Expansive Thinking; Realization of Long-term Ramifications
 - ... by Individuals/Institutions in Positions to Affect Positive Change

Hybrid Configuration Today: Renewable Energy >> High Pressure Electrolyzer

Verdant Turbine

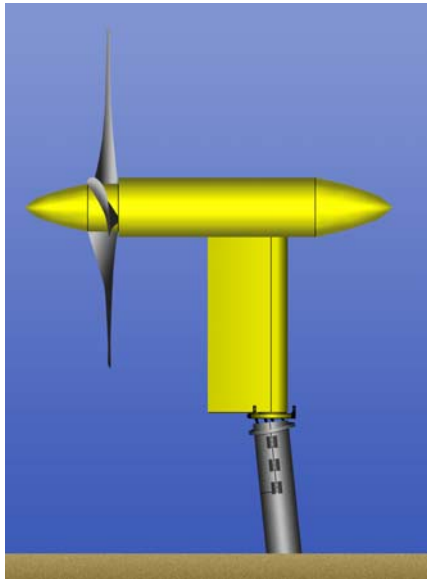


Avalence Hydrofiller

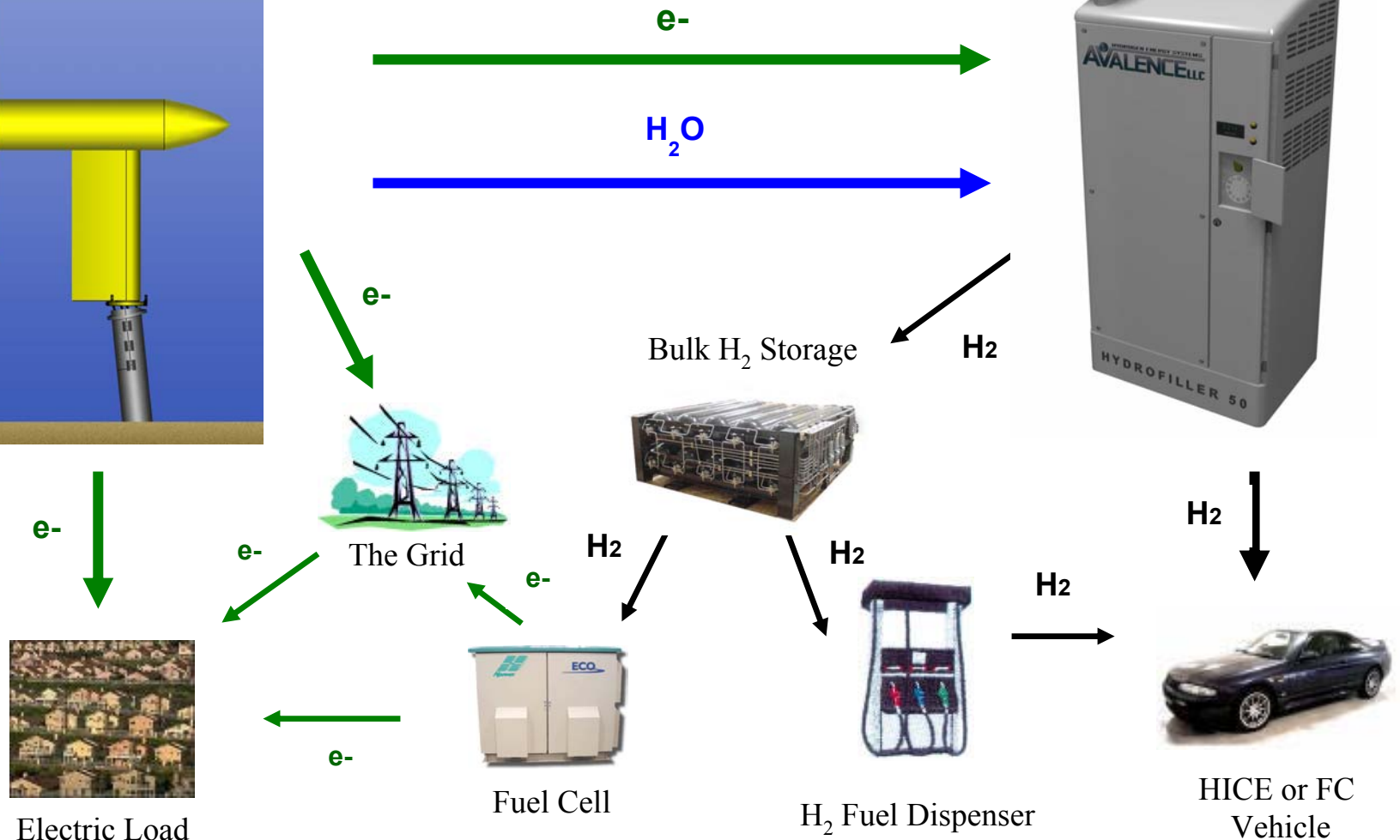


Hybrid Configuration for Future Hydrogen Economy

Verdant Turbine



Avalence Hydrofiller





California Partnerships Public, Private, NGO/Fdn., Academia



California Energy Commission –
Support to benefit CA ratepayers



The Natural Step -
Peer-reviewed,
whole-systems
framework to
environmental and
social sustainability;
integrates long-term
sustainability into
strategic planning.

**Lawrence
Berkeley
National
Laboratory –**
Nationally
renowned
Scientific and
Technical
Expertise



Verdant Power – Free-flow
hydropower systems; renewable
energy, economic development





California Partnerships Public, Private, NGO/Fdn., Academia



Cooper Union for
Advancement of
Science and Art



SF DOE

SF Environment



VERDANT POWER



Leadership Team

- **Ron Smith: *Chairman & COO*** - Booz-Allen; Bendix; Harvard MBA; MS
- **Matt Klein, CFA: *CEO*** - Principal, Robertson Stephens, Founder, Equity Partnerships; ED, Charitable Foundation; Director, NGOs & Start-ups
- **Kevin Lynch, CPA: *CFO*** - Founder, Dieterle & Lynch; MS Taxation
- **Trey Taylor: *President*** - BGE; Price Waterhouse; EEI; P&G; ITT Corp.
- **Jameel Ahmad, PhD: *Senior Advisor*** - Professor and Chairman, Department of Engineering, The Cooper Union for the Advancement of Science and Art; Director, The CU Research Foundation, Fellow at Research Institute for the Study of Man
- **Dean Corren: *Director of Technology Development*** - NYU Scientist, 4-term Vermont Representative, Outreach Director for U.S. Representative
- **Gilbert Sperling: *Corporate Attorney*** - Former Senior Counsel, Energy Conservation and Power Subcommittee, U.S. House of Representatives
- **World-class Board of Directors and Board of Advisors**



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